MORPHOLOGICAL STUDY OF CARYA ALBA AND JUGLANS NIGRA

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(WITH PLATES XV, XVI, AND ONE FIGURE)

The systematic position of the Juglandaceae has been somewhat disputed, some workers having referred the family to the close vicinity of the Anacardiaceae, although the floral structure is very different, and the resiniferous ducts so characteristic of these are totally absent from the Juglandaceae. Since the floral structure has been incorrectly explained in American manuals, it is thought advisable to redescribe this. Moreover, there are several points with regard to the internal structure and the germination which may be of interest to the student of plant morphology, besides that the American representatives are very little known from this particular point of view.

Flower

According to EICHLER,[1] the staminate flower of *Carya* (fig. 1) consists of two prophylla (*P*), which grow together with the subtending bract (*L*), thus forming a three-lobed involucre (figs. 2, 3) suggesting that of *Carpinus;* there is no perianth. The stamens, two to ten, have very short filaments, and are free (fig. 4). In the pistillate flower (figs. 5, 6) the bract is much longer than the two prophylla and the single, or very seldom two perianth-leaves (figs. 7, 8). In other words, the staminate flower has a three-lobed involucre, but no perianth; on the other hand, the pistillate has a very rudimentary perianth, consisting of a single leaf, or very seldom of two minute leaves.

This simple and natural explanation of the floral structure, however, has been ignored or completely misunderstood by subsequent writers in this country. It is strange to see the incorrect description that has been given in the treatments of the North

[1] EICHLER, A. W., Blüthendiagramme. **2**:32. 1875.

American flora. For instance, in GRAY'S *New manual of botany*[2] the staminate flower of the Juglandaceae is said to have "an irregular calyx adnate to the bract," and the pistillate flower to have "a regular 3–5-lobed calyx adherent to the ovary." Furthermore, under *Carya* the staminate flower is simply described as "stamens 3–10; filaments short or none, free," while "a four-toothed calyx; petals none" is attributed to the pistillate flower.

SARGENT[3] describes the staminate flower of *Carya* as follows: "Calyx usually 2-, rarely 3-lobed, subtended by an ovate acute elongated bract free nearly to the base, and usually longer than the ovate rounded calyx-lobes." In the pistillate flower the calyx is said to be "reduced to a single posterior lobe," and the ovary to be "inclosed in a perianth-like slightly 4-ridged involucre, composed by the more or less complete union of an anterior bract and 2 lateral bractlets, adnate below to the ovary, unequally 4-lobed at the apex."

BRITTON[4] describes the staminate flower of Juglandales as "consisting of 3–numerous stamens with or without an irregularly lobed perianth adnate to the bractlet," and the pistillate "bracted and usually 2-bracteolate with a 3–5-lobed (normally 4-lobed) calyx or with both calyx and petals." Under *Hicoria* the staminate flower is said to possess "a calyx adnate to the bract, 2–3-lobed or 2–3-cleft," and the pistillate flower is described as "bract fugacious or none; calyx 4-toothed; petals none." This same description is reprinted in the second edition of BRITTON and BROWN'S *Illustrated flora*.

By SMALL[5] the staminate flower of the Juglandales is said to possess "a 2–6-lobed calyx bearing several rows of stamens, or the calyx obsolete," while the pistillate flower is described as "consisting of an involucrate incompletely 2–4-celled gynaecium: calyx partially adnate to the gynaecium." Under *Hicoria* the staminate

[2] ROBINSON and FERNALD, A handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. p. 330. 1908.

[3] SARGENT, C. S., The Silva of North America. **7**: 1895.

[4] BRITTON, N. L., Manual of the flora of the Northern States and Canada. 3d. ed. p. 322. 1907.

[5] SMALL, J. K., Flora of the southeastern United States. 2d. ed. p. 332. 1913.

flower is described as "a 3-lobed calyx," and the pistillate as "a calyx of 1 sepal adnate on the ovary."

With respect to the flowers of *Juglans*, EICHLER describes the staminate flower (fig. 10) as consisting of two prophylla (*P*), which with the two to five perianth leaves grow together with the subtending bract; the six to forty stamens have very short, free filaments. The pistillate flower has a superior, four-leaved perianth; the ovary, bract, and prophylla all unite together, their edge being visible as an indented line below the perianth (fig. 13). The staminate flower, therefore, has two prophylla and a two to four-leaved perianth, which grow together with the subtending bract; the pistillate has a superior perianth of four leaves, and the subtending bract beside the two prophylla grow together with the ovary.

As was the case of *Carya*, this very simple structure has been completely misunderstood by subsequent writers in this country. ROBINSON and FERNALD do not describe the staminate flower of *Juglans* in any other way than "stamens 12–40; filaments free, very short." On the other hand, the pistillate flower is said to possess "a four-toothed calyx, bearing four small petals at the sinuses."

SARGENT attributes "a perianth sessile or pedicellate, three to six-lobed in the axil of an adnate to an ovate acute bract free only at the apex" to the staminate flowers. The pistillate flower is described as being invested by a villous involucre adnate to the ovary, and formed by the union of the anterior bract, sometimes free nearly to the base, and two lateral bractlets free only at the apex, and variously cut into a laciniate border shorter than the erect lanceolate calyx lobes inserted at the summit of the ovary.

By BRITTON the staminate flower of *Juglans* is said to have a "perianth 3–6-lobed," and the pistillate "calyx 4-lobed, with 4 small petals adnate to the ovary at the sinuses." SMALL describes the staminate flower in the same manner, while the pistillate is said to have "the sepals adnate to the ovary."

In "*Flora of the District of Columbia and vicinity*," published under the auspices of the Smithsonian Institution (1919), no

description is given of the floral structure, except that the fruit is "a nut inclosed in a shuck or husk, the meat or embryo 4-lobed."

Carya alba

Root

The primary structure may be studied from the thin lateral roots of the seedling. No secondary increase takes place during the first season; thus the epidermis and cortical parenchyma remain intact. The latter consists of about ten compact strata, and the endodermis is very thick-walled, representing a U-endodermis. A thin-walled pericambium of a single layer surrounds the pentarch stele, in which thick-walled conjunctive tissue is much in evidence, surrounding the vessels, and as a narrow group in the center of the stele. On the other hand, increase in thickness is readily noticeable in the primary root of the seedling in its second year. In this the epidermis and the primary cortex have become thrown off, replaced by many layers of homogeneous, thin-walled cork of pericambial origin. Inside the cork is a narrow zone of thin-walled parenchyma, which surrounds a circular band of small strands of stereome (fig. 9, *St*), supporting the leptome (*L*) of the secondary mestome strands. There is now a continuous ring of cambium, from which the secondary mestome is developed, and the thickness of the root depends largely upon the presence of a very broad, central, thin-walled parenchyma, a true pith, containing starch in abundance, but no crystals.

The development of stereome in the root deserves attention, since, so far as known, this tissue does not appear to be commonly represented in roots. In *Carya* it is a secondary structure, which seems to be the general case wherever it occurs in roots. As a primary structure the stereome is extremely rare, known only in a very few genera, *Dirca*, *Anona*, *Celtis*, etc., where it is developed in the primary leptome.

Stem

The apical internode of the seedling is densely covered with hairs of different types, unicellular, long, pointed, which are either single or developed in tufts; and large, sessile, pluricellular, glandular of peltate shape. The cuticle is smooth and the epidermis

is quite thick-walled. The cortex is differentiated into a peripheral sheath of collenchyma, three or four strata, and an interior of thin-walled parenchyma, five to six layers. Rhombic crystals of calcium oxalate were observed in the collenchyma, while aggregated crystals occurred sparingly in the inner part of the cortex. The phellogen arises in the hypodermal stratum of the collenchyma. A thin-walled, starch-bearing endodermis surrounds a band of small isolated strands of stereome, separated from each other by narrow rays of parenchyma. The stele shows a continuous zone of leptome, cambium, and hadrome in deep rays, accompanied by many layers of libriform. A homogeneous, slightly thick-walled pith, destitute of starch, occupies the central portion of the stele; the pith is not septate.

In branches of the mature tree the cork appears in many thin-walled strata; the stereome is well represented as several, until seven, concentric bands of isolated strands, the result of one season's growth. Large rhombic crystals abound in the leptome, and the hadrome is divided by broad tangential bands of moderately thickened libriform. The very thick-walled, porous vessels so characteristic of *Juglans* do not occur in *Carya*, and the pith is nowhere septate.

Leaf

Viewed in superficial sections the ventral epidermis shows the lateral cell walls prominently undulate, hairs and stomata being absent. In the dorsal epidermis the lateral walls are less undulate, but stomata and hairs are abundant; of these the former are all of the same size, and surrounded by four to seven ordinary epidermis cells; the hairs are of the same types as observed upon the stem.

Viewed in transverse sections the cuticle is thick and smooth on both faces of the leaf blade, and the outer cell wall of epidermis is thickened. Large oil drops abound in the ventral epidermis. The mesophyll consists of a typical palisade tissue of one stratum, covering a very open pneumatic tissue of three to five layers. Numerous large cells containing aggregated crystals are scattered in the palisade tissue, while single rhombic crystals abound in the pneumatic tissue, especially close to the veins.

The midrib of the leaflet has a very thick-walled epidermis, and a few hypodermal strata of collenchyma on both faces, bordering on a water-storage tissue with many aggregated crystals. There is no endodermis, but a closed sheath of stereome, which surrounds a stele of several collateral mestome strands, all of which turn the leptome toward the periphery, and with the hadrome bordering on a central pith. The pith is thin-walled, and contains some few crystals, aggregated as well as single, rhombic. The much thinner lateral veins are more or less imbedded in the mesophyll, and contain only one mestome strand, surrounded by a chlorophyll-bearing parenchyma sheath. The structure of the rhachis and the petiole is identical with that of the midrib, thus containing a typical stele of several mestome strands, a sheath of stereome, and a cortex of which the peripheral strata are collenchymatic.

Juglans nigra

SEEDLING

In the Juglandaceae the cotyledons are hypogeic in all the species examined, with the exception of *Pterocarya caucasica* C. A. Mey., which germinates with the cotyledons above ground. It is a marked characteristic of the Dicotyledons that the cotyledons are epigeic, and it is only in a relatively few families that they remain underground, serving only as storage organs. Subterranean cotyledons, however, are known from trees, shrubs, and herbs, terrestrial as well as aquatic, but the Nymphaeaceae is the only family in which all the species, so far as known, germinate with the cotyledons underground and inclosed within the seed. In the other families subterranean cotyledons are characteristic of some certain groups, for instance, Vicieae, or genera: *Phryma*, *Sanguinaria*, *Caulophyllum*, *Panax*, *Melittis*, *Collinsonia*, *Quercus*, *Castanea*, *Aesculus*, *Sassafras*, *Citrus*, *Aegle*, *Mangifera*, *Persea*, *Prunus*, etc. While in some genera the majority of the species germinate with epigeic cotyledons, some exceptions occur, for instance in *Anemone*, *Oxalis*, *Clematis*, *Aristolochia*, *Phaseolus*, *Rhamnus*, etc., where some few species have the cotyledons constantly subterranean.

Characteristic of the seedlings with hypogeic cotyledons is the generally strong development of the primary root. In the Nymphaeaceae, *Nuphar*, *Nymphaea*, and *Victoria*, however, the primary

root increases but little in length during the first stages of germination, its function becoming performed by a whorl of very long root hairs developing from the base of the root as soon as the seed germinates. In *Nelumbium*, on the other hand, the root remains rudimentary, and no whorl of hairs becomes formed.[6]

The structure of the seedling of *Juglans nigra* (text fig. 1) agrees with that of *J. regia* L. as described by SCHACHT[7] and KLEBS.[8] The primary root (*R*) is stout and quite long, but it is not fusiform as in *Carya*. There is no hypocotyl, and the cotyledons remain underground, inclosed, or partly so, by the bony endocarp. They are short petioled, auriculate at base, two-lobed, and the lobes bifid. The petioles form a sheath (*S*) around the plumule, which during the first season develops into a glabrous short shoot. The first four or five leaves are very small, scalelike, and entire; the

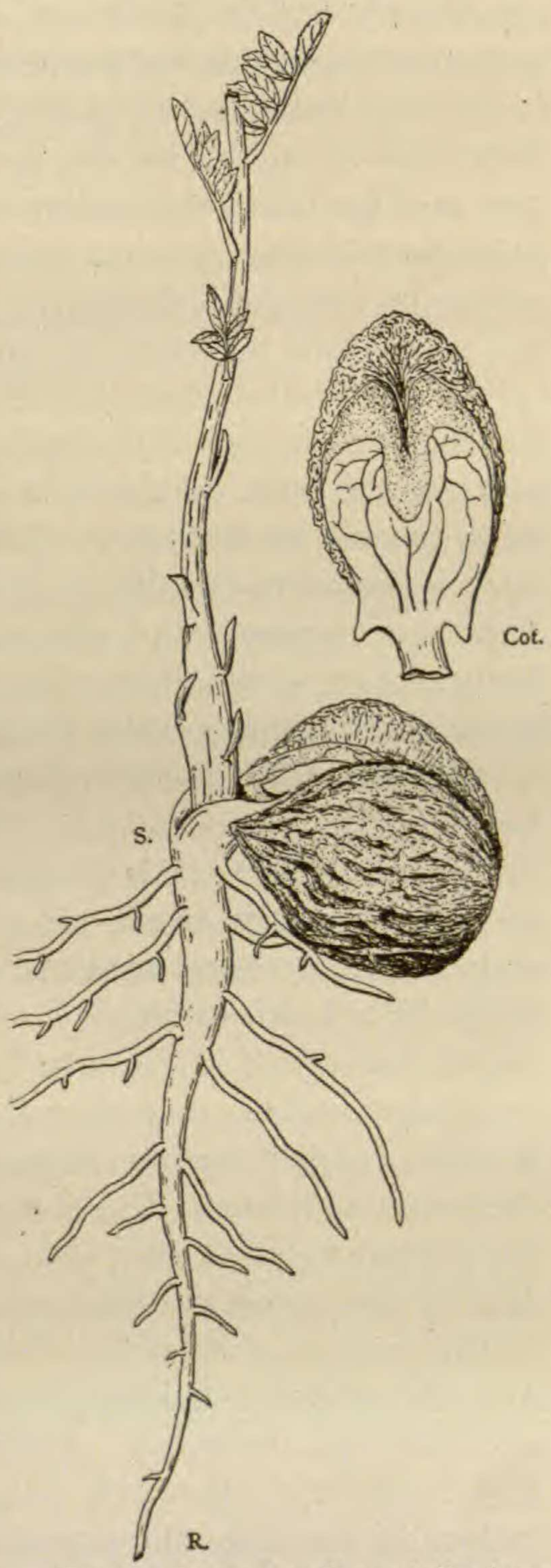


FIG. 1.—Young seedling of *J. nigra*, showing primary root (*R*), sheath formed by cotyledons (*S*), and aerial shoot; two-thirds natural size.

[6] POITEAU, Mémoire sur l'embryon des Graminées, des Cypéracées, et du *Nelumbo*. Ann. Mus. Hist. Nat. 13:397. 1809.

MIRBEL, B., Observations anatomiques et physiologiques sur le *Nelumbo nucifera*. *Ibid.* p. 474.

[7] SCHACHT, H., Beiträge zur Anatomie und Physiologie der Gewächse. p. 105. 1854.

[8] KLEBS, G., Beiträge zur Morphologie und Biologie der Keimung. Untersuch. Bot. Inst. Tübingen 1:556. 1881–1885.

succeeding are small, odd-pinnate, with three to seven leaflets. Buds are present in the axils of all the leaves, including the cotyledons; and in specimens which were injured at the apex, several of these buds had grown out into erect shoots (fig. 1).

In *Carya alba* and *C. glabra* (Mill.) Spach the seedlings agree with those of *Juglans*, but the root is fusiform. Moreover, the first two or three leaves succeeding the scalelike are unifoliate to trifoliolate, with the terminal leaflet very large, roundish, and far surpassing the lateral in size.

ROOT

The primary root of the seedling is stout and fleshy at the base, owing to the large development of the parenchymatic tissues, primary as well as secondary. The successive development of the various tissues may readily be seen in the same root, when examined from base to apex. In beginning with the basal swollen portion, the structure is as follows. Only some few, more or less broken strata of the primary cortex and part of the endodermis still adhere to the root, which is now covered by four or five layers of thin-walled cork of pericambial origin. Inside the cork is a broad parenchyma, the secondary cortex, rich in starch, and interrupted by two concentric bands of isolated strands of stereome. The stele shows an almost continuous zone of leptome and cambium, while the hadrome corresponds with eight distinct mestome strands. On the inner flank of the interfascicular cambium some few young vessels are visible; moreover, there are four rays of narrow protohadrome vessels readily distinguishable from the secondary by their narrow lumen. The central portion of the stele is occupied by a broad starch-bearing pith. In comparing this structure with that of the younger apical part of the same root, the following distinctions are noticeable. There is a glabrous epidermis, destitute of root hairs, and the primary cortex is a broad parenchyma without starch or crystals. Inside the endodermis is a pericambium of a single layer, in which tangential divisions have commenced, indicating the beginning formation of the cork (fig. 15, *Co*). Bordering on the pericambium is a zone of about eight layers of thin-walled parenchyma (fig. 15, C^+), representing a secondary cortex.

This tissue does not contain starch or crystals, but is interrupted, here and there, by narrow strands of secondary leptome, covered by young thin-walled stereome (fig. 16, *St*), in two concentric bands. Then follows a continuous zone of cambium connecting the four collateral mestome strands, and from which (the cambium) some few young, wide, porous vessels have become developed. Beside this secondary mestome the protohadrome vessels are very distinct, forming four short narrow rays of annular and spiral vessels.

The very commencement of the formation of these secondary tissues, the cortex and the collateral mestome strands, but not the cork, can only be traced at the youngest, the apical, portion of this root. The earliest appearance of the secondary formations depends upon a double meristem arising along the inner flank of the primary leptome, and from which secondary leptome and hadrome become formed. Outside the protohadrome the pericambium then commences to divide, forming another meristem, which in *Juglans* gives rise first to parenchyma, a secondary cortex, and a little later to a peripheral cork. Regarding the stereome, so amply represented in the secondary cortex, this tissue is totally absent from the primary structure of this root. It arises outside the leptome (fig. 16, *St*), and is formed by the secondary cortex, soon developing to distinct separate strands, arranged in one or several more or less concentric bands.

In old, thick, lateral roots the epidermis and the primary cortex are replaced by many layers of thin-walled, homogeneous cork, which surround a broad zone of compact thin-walled parenchyma (secondary cortex), the cells of which contain much starch and numerous aggregated crystals of calcium oxalate. In this secondary cortex are five or six concentric bands of isolated stereome strands (fig. 17, *St*). Viewed in longitudinal sections these stereome strands traverse the parenchyma in wavy, not parallel lines. The stele contains a peripheral zone of almost continuous leptome, also several strata of cambium, beside a dense mass of hadrome, in which wide porous tracheids with bordered pits are quite conspicuous. Thick-walled libriform, and thin-walled parenchyma with starch represent also a large part of the stele. The medullary

rays (fig. 17, *PR*) are narrow, mostly of a single row of cells, compressed radially, and filled with starch. The protohadrome vessels are readily seen in the center of the root, surrounded by strata of thick-walled conjunctive tissue; no pith is developed.

STEM

The young shoot, examined in the early spring, is densely covered with hairs, especially glandular. Unicellular, pointed hairs are also common, and these occur in clusters of from two to fifteen, or even more. The cuticle is thick, smooth, and the epidermis is thick-walled. During the fall the epidermis is replaced by a hypodermal cork of heterogeneous structure, thin-walled strata alternating with thick-walled. This cork is developed from the hypodermal stratum of a collenchyma. Inside the collenchyma is a broad, compact, thin-walled parenchyma, filled with starch and large aggregated crystals. Two concentric bands of stereome are developed in the inner part of the cortex. There is no endodermis, and the stele shows a continuous zone of leptome, interspersed with cells containing single rhombic crystals. The cambium is well represented, and in the hadrome the porous vessels are remarkably thick-walled. Cells containing single crystals occur also in the hadrome. The medullary rays are narrow, mostly of a single row of cells, containing starch. There is a relatively thick-walled pith, porous, filled with starch and aggregated crystals, and becoming soon septate as in *Juglans regia* and *Pterocarya*, as mentioned by SOLEREDER. A corresponding structure is exhibited by the old thick branches, but in these the stereome occurs in a larger number of concentric bands, twelve or even more. The pith also is here divided by transverse septa.

Finally may be mentioned that the internodes of the young seedling are perfectly glabrous, and a cork is developed from the hypodermal layer of the cortex, or from the stratum inside this; both cases may be observed in the same section. There is no collenchyma in these internodes during the first season, and the cortex is thin-walled throughout, destitute of starch and crystals. Inside the barely distinguishable endodermis are four or five layers of thick-walled stereome, forming arches, more or less continuous

as a closed sheath. Bordering on the stereome is a broad zone of thin-walled parenchyma, with narrow isolated strands of leptome. The cambium forms a closed ring, and the hadrome is in deep rays with much thick-walled libriform. The pith is homogeneous, thin-walled, filled with starch, but solid, not septate as in the shoots of the mature tree.

LEAF

When unfolding, the leaves are very hairy, especially on the dorsal face, and the hairs are of the types that occur on the young shoots. The stomata are confined to the dorsal face, and lack subsidiary cells. They represent two sizes, both of which are equally common. Viewed in superficial sections the lateral walls of epidermis are straight on both faces of the leaf blade. With regard to the distribution of the various hairs, the pointed, fasciculate, abound beneath the veins, and are absent from the ventral face; the glandular are common on both faces; but the largest type, sessile with a large head, are confined to above and below the mesophyll. The mesophyll consists of a compact palisade tissue of a single stratum, or sometimes two strata (fig. 18, *P*), covering a very open pneumatic tissue with numerous large cells containing aggregated crystals, especially close to the epidermis.

The midrib is supported by several hypodermal layers of collenchyma on both faces, and is furthermore surrounded by a water-storage tissue. There is no endodermis, but a closed sheath of thick-walled stereome in several strata surrounding the steloid midvein, which is composed of an obtusely triangular band (in cross-sections) of collateral mestome strands inclosing a central parenchyma, a pith. In these mestome strands the hadrome faces the pith, while the leptome turns toward the periphery, even in the ventral part of the stele. Characteristic of the hadrome is the abundance of thin-walled parenchyma in continuation with the vessels. The lateral veins contain only single mestome strands which are supported by stereome extending to the ventral and dorsal epidermis, broken on the sides by thin-walled cells of a parenchyma sheath.

Between the leaflets the rhachilla is hemicylindric (in cross-sections), very hairy, with long stalked glandular hairs. Several

hypodermal and continuous layers of collenchyma surround a broad thin-walled cortex, rich in chlorophyll, and with some aggregated crystals. No endodermis is developed, but a closed sheath of stereome surrounds a stele of collateral mestome strands as in the midrib of the blade. The pith is solid, not divided into septa.

Examined just below the basal pair of leaflets, the petiole is hairy like the rhachilla, and shows the same structure, except that there are two thin collateral mestome strands located in the cortex, thus outside the stele, and in these the leptome is covered by a few layers of stereome; the pith is solid.

COTYLEDONS

Although completely subterranean, the epidermis of the cotyledons shows stomata, but relatively only a few, on both faces of the thick fleshy blade. The lateral cell walls are straight on both faces, and the lumen is about the same, or slightly wider on the ventral face. The mesophyll lacks palisade cells, and is composed of a large, thin-walled, compact parenchyma of roundish cells. All the mestome strands are single, collateral, surrounded by parenchyma sheaths, and are imbedded in the mesophyll. The leptome is generally much better represented than the hadrome, and no mechanical tissues are developed in these leaves.

Juglans cinerea shows the same structure as *J. nigra*, with the only exception that the pericycle in the stem represents an almost closed sheath interspersed with large, thick-walled, and porous sclereids. The pith is discoid, and the diaphragms contain many aggregated crystals. The pointed hairs of the leaf are more abundant than in *J. nigra*, and occur mostly in clusters of two to eight on the dorsal face of the blade.

Characteristic of *Juglans* and *Carya* is thus the ample representation of mechanical tissues, as collenchyma, stereome, and liriform. Of these the collenchyma occurs in the stem, the periphery of the cortex proper, and in the leaves as hypodermal strata on both faces of the midrib. The stereome occurs as a secondary tissue in the cortex of the root and stem, as well as pericyclic arches or, sometimes, forming a closed sheath, interspersed with sclereids

in *J. cinerea;* it occurs also in the leaves forming a sheath around the midrib. Thick-walled libriform is noticeable already in the apical internodes of the seedling, and in branches of the mature tree the hadrome is divided by broad tangential bands of this tissue. In old roots of *Juglans* the libriform is much in evidence.

With respect to the distribution of the calcium-oxalate as single or aggregated crystals, SOLEREDER (Anatomie Dicot.) calls attention to the very varied occurrence of these types of crystals. In *Juglans nigra* aggregated crystals were observed in the inner part of the cortex and pith of the stem, as well as in the pneumatic tissue of the leaf. On the other hand, single crystals were noticed in the leptome and hadrome of the stem. In *Carya alba* aggregated crystals were observed in the cortex and leptome of the stem, as well as in the palisade tissue of the leaf, and in the pith of the steloid midrib. Single crystals, on the other hand, were found in the collenchyma of the stem, as well as in the pneumatic tissue of the leaf and in the pith of the steloid midrib; thus both types of crystals occur in the pith of the midrib.

Of greater interest, however, is the singular structure of the pith in *Juglans* and *Pterocarya*. The history of this structure, the discoid pith, dates back to GREW,[9] who discovered it in *Juglans*. By MIRBEL[10] it was mentioned as peculiar to *Phytolacca*, *Nyssa*, and *Juglans*. DE CANDOLLE[11] found a discoid pith in *Jasminum officinale*. MORREN,[12] in describing discoid piths of plants, enumerates several other plants, for instance, *Begonia argyrostigma*, while this writer found the pith to be solid in *B. undulata*, *B. semperflorens*, and *B. papillosa*. According to SOLEREDER the discoid pith is characteristic of two herbs, *Diplotaxis* and *Pedalium*, and among woody plants he enumerates *Wormia* (Dilleniaceae), *Fouquiera* (Tamariscineae), *Prinsepia* (Chrysobalanaceae), *Aucuba*, *Halesia*, *Paulownia*, *Daphniphyllum* (Daphniphyllaceae), as well as the

[9] GREW, N., Anatome plantarum. *pl. 19. fig. 4.* 1682.

[10] MIRBEL, B., Elémens de Physiologie végétale et de Botanique. 1:112. 1815.

[11] DE CANDOLLE, A. P., Organographie. 1:167. 1827.

[12] MORREN, C., On the discoid piths of plants. Ann. Nat. Hist. London. 4:73. 1839–1840.

genera mentioned in the preceding. By FOXWORTHY[13] a general discussion of discoid pith has been presented. Finally by the writer[14] the structure of the pith in *Phytolacca decandra* L. has been described and figured.

While the discoid pith is thus characteristic of the species of certain genera, it has been shown that in *Begonia*, *Forsythia*, *Jasminum*, and *Phytolacca* this structure occurs only in certain species. *Juglans* and *Pterocarya* are definitely separated from the other genera by the possession of a discoid pith. It is a very interesting structure, which, however, must not be confounded with cases where the pith is solid, and divided by horizontal diaphragms of sclerotic cells, so characteristic of many Magnoliaceae, Anonaceae, Ternstroemiaceae, and Convolvulaceae.

CLINTON, MD.

EXPLANATION OF PLATES XV, XVI

PLATE XV

Carya alba

Figs. 2, 3, 4, 7, 8, 10, 11, 13, and 14 are enlarged.

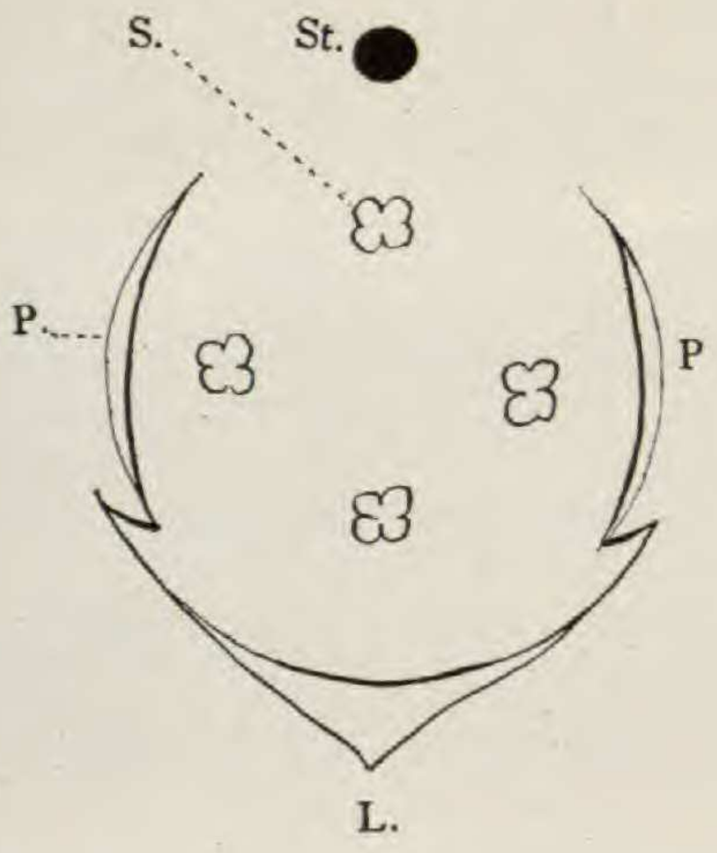
FIG. 1.—Staminate flower: *St*, stem; *L*, bract; *P*, prophylla; *S*, stamens.
FIG. 2.—Involucre of staminate flower, seen from outside.
FIG. 3.—Staminate flower, side view.
FIG. 4.—Stamen.
FIG. 5.—Pistillate flower: *PL*, perianth leaves; other letters as preceding.
FIG. 6.—Pistillate flower with single perianth leaf.
FIG. 7.—Pistillate flower, side view; *PS*, petiole.
FIG. 8.—Pistillate flower, seen from above.
FIG. 9.—Cross-section of inner part of primary root of seedling in second year: *St*, stereome strands outside secondary leptome (*L*); *Camb*, cambium; *H*, hadrome; *PR*, parenchymatic ray; *P*, pith; × 320.

Juglans nigra

FIG. 10.—Staminate flower, seen from outside; stamens removed.
FIG. 11.—Two stamens, side and front view.
FIG. 12.—Branch with pistillate flowers; natural size.
FIG. 13.—Longitudinal section of pistillate flower; *P*+, perianth leaves.
FIG. 14.—Cross-section of stigma.

[13] FOXWORTHY, E. W., Discoid pith in woody plants. Proc. Indiana Acad. Sci. p. 191. 1903.

[14] HOLM, THEO., Medicinal plants of North America. 9. *Phytolacca decandra* L. Merck's Report. p. 312. 1907.



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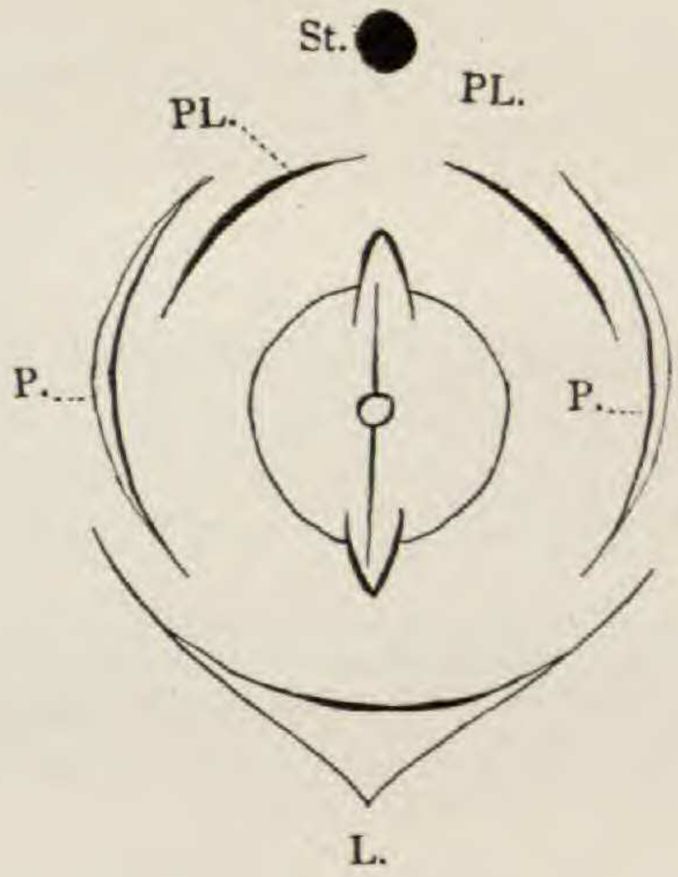

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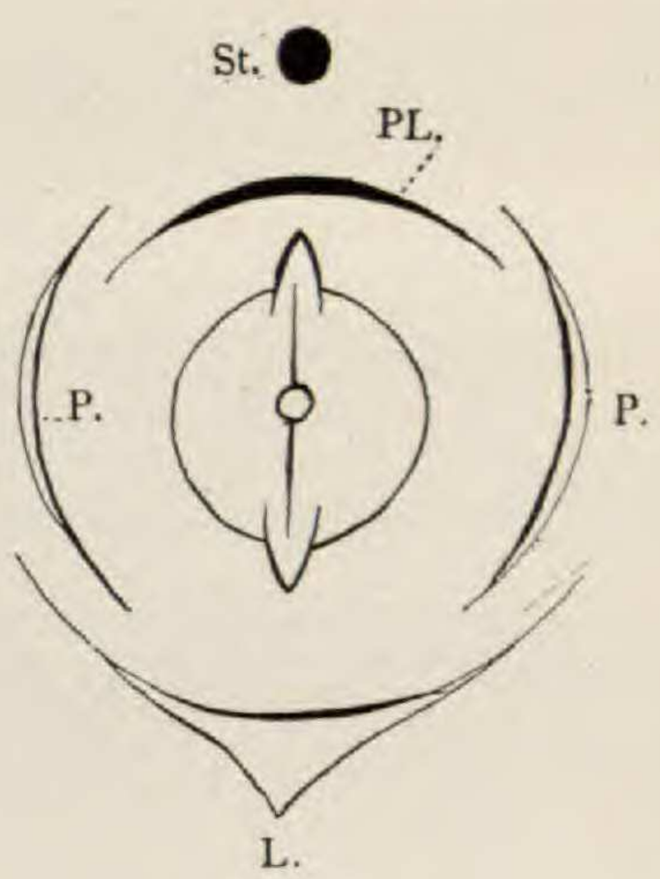

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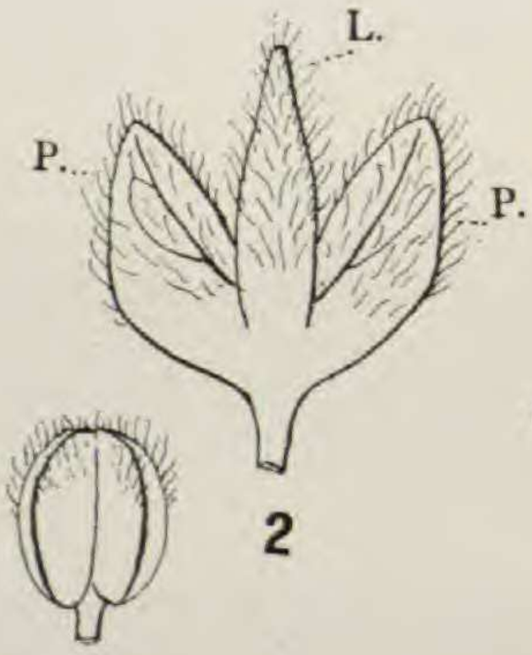

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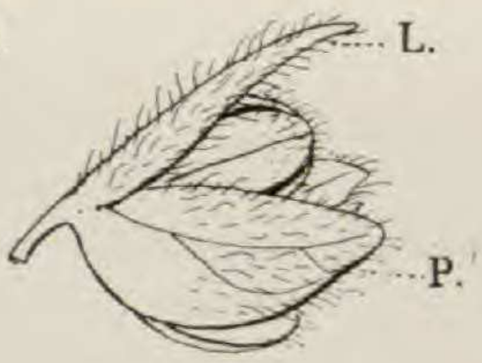

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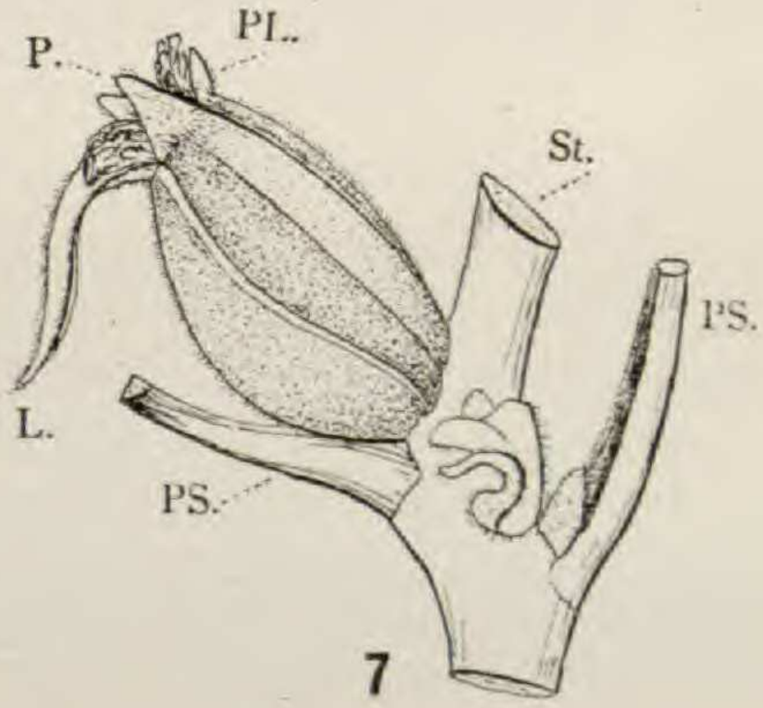

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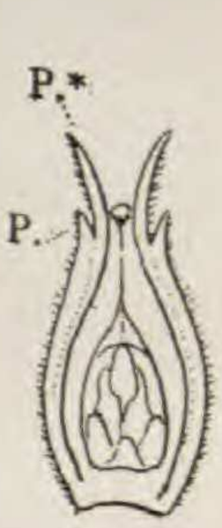

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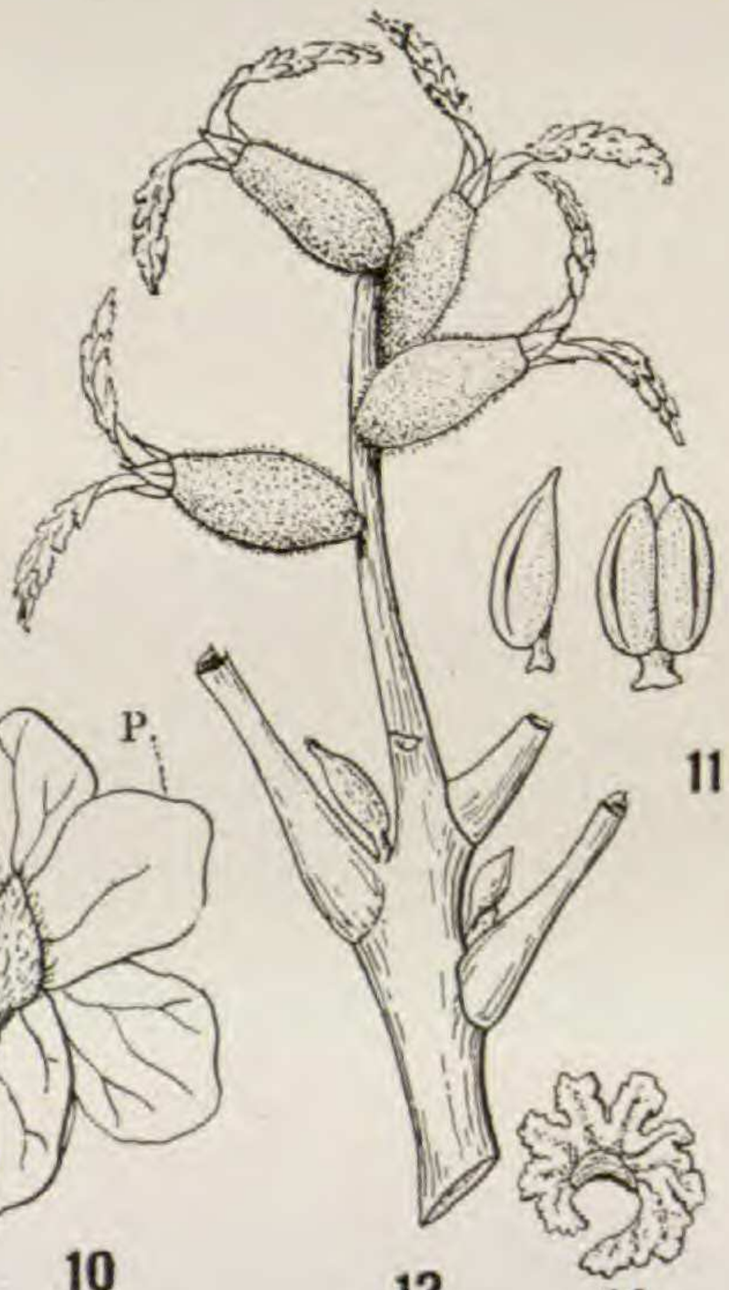

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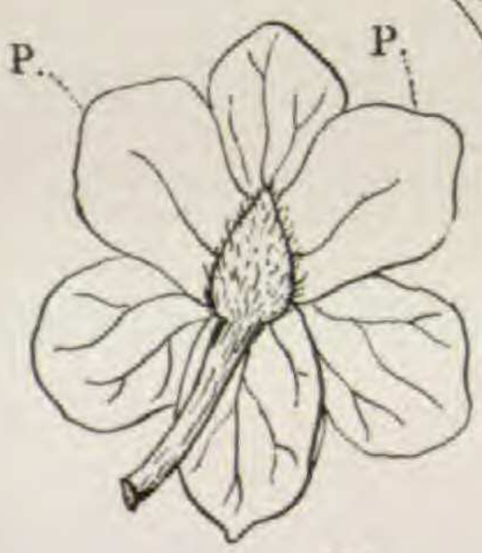

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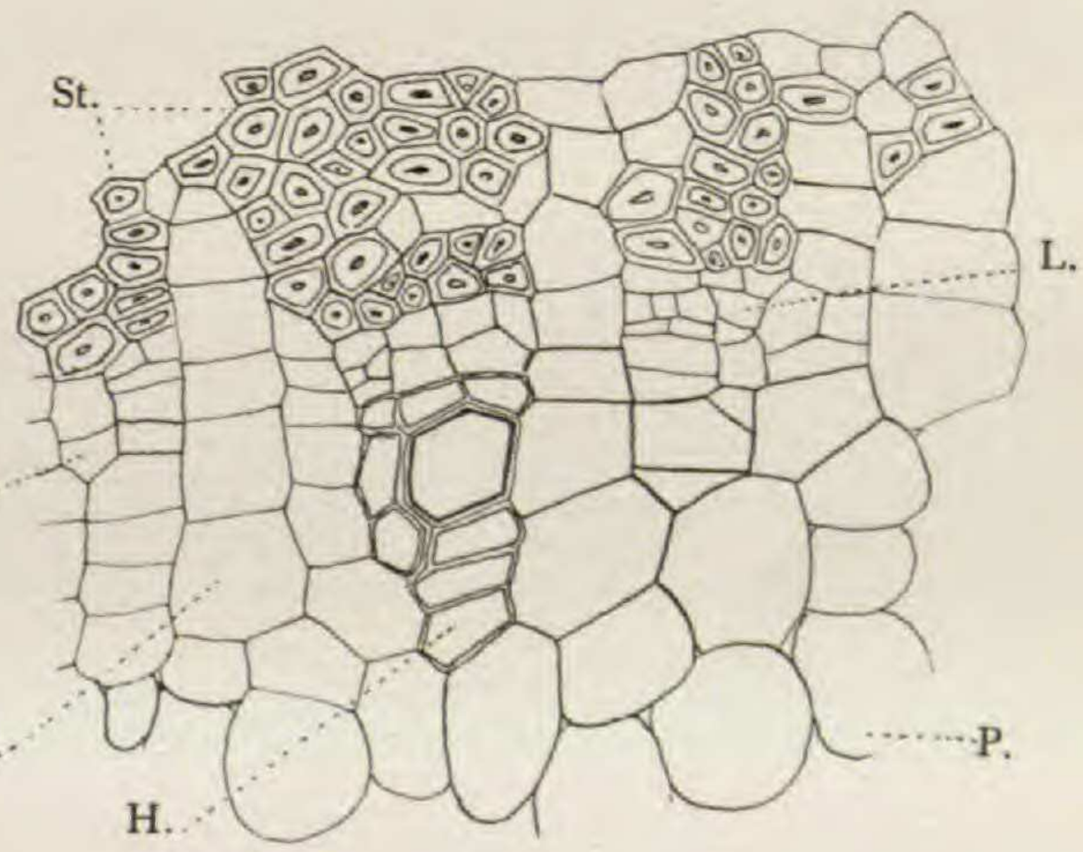

9

HOLM on CARYA and JUGLANS